CLAIMS

What is claimed is:

1. A composition for use as a catalyst in oxidation or reduction reactions, the composition comprising platinum and copper, wherein (i) the concentration of platinum is greater than 50 atomic percent and less than about 80 atomic percent, and (ii) the composition has a particle size which is less than 35 angstroms (Å).

2. The composition of claim 1 wherein the sum of the concentrations of platinum and copper therein is greater than about 95 atomic percent.

3. The composition of claim 1 or 2 wherein said composition comprises an alloy of platinum and copper.

4. The composition of claim 1 or 2 wherein said composition consists essentially of an alloy of platinum and copper.

5. The composition of one of the preceding claims wherein the composition has a particle size which is greater than about 20 angstroms and less than 35 angstroms.

6. The composition of one of the preceding claims wherein the composition has a particle size which is greater than about 25 angstroms and less than 30 angstroms.

7. The composition of one of the preceding claims wherein the concentration of platinum is greater than about 60 atomic percent and less than about 80 atomic percent.

8. The composition of one of the preceding claims wherein the concentration of platinum is greater than about 65 atomic percent and less than about 75 atomic percent.

9. A supported electrocatalyst powder for use in electrochemical reactor devices, the supported electrocatalyst powder comprising the composition of any one of claims 1-8 on electrically conductive supports.

10. A fuel cell electrode, the fuel cell electrode comprising electrocatalyst particles and an electrode substrate upon which the electrocatalyst particles are deposited, the electrocatalyst particles comprising the composition of any one of claims 1-8.

11. The fuel cell electrode of claim 10 wherein the electrocatalyst particles comprise the supported electrocatalyst powder of claim 9.

12. A fuel cell comprising an anode, a cathode, a proton exchange membrane between the anode and the cathode, and the composition of any one of claims 1-8 for the catalytic oxidation of a hydrogen-containing fuel or the catalytic reduction of oxygen.

13. The fuel cell of claim 12 wherein the composition is on the surface of the proton exchange membrane and in contact with the anode.

14. The fuel cell of claim 12 wherein the composition is on the surface of the anode and in contact with the proton exchange membrane.

15. The fuel cell of claim 12 wherein the composition is on the surface of the proton exchange membrane and in contact with the cathode or it is on the surface of the cathode and in contact with the proton exchange membrane.

16. A method for the electrochemical conversion of a hydrogen-containing fuel and oxygen to reaction products and electricity in a fuel cell comprising an anode, a cathode, a proton exchange membrane therebetween, the composition of any one of claims 1-8, and an electrically conductive external circuit connecting the anode and cathode, the method comprising contacting the hydrogen-containing fuel or the oxygen and the composition to catalytically oxidize the hydrogen-containing fuel or catalytically reduce the oxygen.

17. The method of claim 16 wherein the hydrogen-containing fuel consists essentially of hydrogen.

18. The method of claim 16 wherein the hydrogen-containing fuel is a hydrocarbon-based fuel selected from the group consisting of saturated hydrocarbons, garbage off-gas, oxygenated hydrocarbons, fossil fuels, and mixtures thereof.

19. The method of claim 16 wherein the hydrogen-containing fuel is methanol.

20. A fuel cell electrolyte membrane having deposited on a surface thereof a layer of an unsupported catalyst composition, said unsupported catalyst composition layer comprising the catalyst composition of any one of claims 1-8.

21. A fuel cell electrode having deposited on a surface thereof a layer of an unsupported catalyst composition, said unsupported catalyst composition layer comprising the catalyst composition of any one of claims 1-8.

22. A method for preparing a catalyst composition from a catalyst precursor composition, said precursor composition comprising platinum and copper, wherein the concentration of platinum therein is greater than about 20 atomic percent and less than about 40 atomic percent, the method comprising

subjecting said precursor composition to conditions sufficient to remove a portion of the copper present therein, such that the resulting catalyst composition comprises platinum and copper, wherein the concentration of platinum therein is greater than 50 atomic percent and less than about 80 atomic percent.

23. The method of claim 22 wherein the composition has a particle size which is less than 35 angstroms (Å).

24. The method of claim 23 wherein the composition has a particle size which is greater than about 20 angstroms and less than 30 angstroms.

25. The method of one of claims 22-24 wherein the concentration of platinum is greater than about 60 atomic percent and less than about 80 atomic percent.

26. The method of one of claims 22-25 wherein the catalyst precursor composition is contacted with an acidic solution to solubilize a portion of the copper present therein.

27. The method of one of claims 22-25 wherein the catalyst precursor composition is subjected to an electrochemical reaction wherein a hydrogen-containing fuel and oxygen are converted to reaction products and electricity in a fuel cell comprising an anode, a cathode, a proton exchange membrane therebetween, the catalyst precursor composition, and an electrically conductive external circuit connecting the anode and cathode, the method comprising contacting the hydrogen-containing fuel or the oxygen and the catalyst precursor composition to oxidize the hydrogen-containing fuel and/or catalytically reduce the oxygen, and to dissolved *in situ* from the catalyst precursor composition copper present therein.

28. The method of claim 27 wherein the hydrogen-containing fuel consists essentially of hydrogen.

29. The method of claim 27 wherein the hydrogen-containing fuel is methanol.

30. The method of one of claims 22-29 wherein the concentration of platinum in the catalyst precursor composition is greater than about 25 atomic percent and less than about 35 atomic percent.

31. A method for preparing a catalyst composition from a catalyst precursor composition, said precursor composition comprising platinum and copper, wherein the concentration of platinum therein is less than 50 atomic percent, the method comprising contacting said precursor composition with an acidic solution having a pH which is greater than 0 and less than 7, to solubilize a portion of the copper present therein, such that the resulting catalyst composition comprises platinum and copper, the concentration of platinum therein being greater than 50 atomic percent.

32. The method of claim 31 wherein the platinum concentration of the catalyst precursor is greater than about 20 atomic percent and less than about 40 atomic percent.

33. The method of one of claims 31 or 32 wherein the concentration of platinum in the resulting catalyst composition is greater than 60 atomic percent and less than about 80 atomic percent.

34. The method of one of claims 31-33 wherein the resulting catalyst composition has a particle size which is less than 35 angstroms (Å).

35. The method of one of claims 31-34 wherein the concentration of platinum in the catalyst precursor composition is greater than about 25 atomic percent and less than about 35 atomic percent.

36. The method of one of claims 31-35 wherein the pH of the acidic solution is greater than 0.5 and less than 3.

37. A method for preparing a catalyst composition from a catalyst precursor composition, said precursor composition comprising platinum and copper, wherein the concentration of platinum therein is less than 50 atomic percent, the method comprising contacting said precursor composition with a solution in air, or alternatively in an atmosphere having an oxygen concentration which is greater than in air, to solubilize a portion of the copper present therein, such that the resulting catalyst composition comprises platinum and copper, the concentration of platinum therein being greater than 50 atomic percent.

38. The method of claim 37 wherein the platinum concentration of the catalyst precursor is greater than about 20 atomic percent and less than about 40 atomic percent.

39. The method of one of claims 37 or 38 wherein the concentration of platinum in the resulting catalyst composition is greater than 60 atomic percent and less than about 80 atomic percent.

40. The method of one of claims 37-39 wherein the resulting catalyst composition has a particle size which is less than 35 angstroms (Å).

41. The method of one of claims 37-40 wherein the concentration of platinum in the catalyst precursor composition is greater than about 25 atomic percent and less than about 35 atomic percent.

42. The method of one of claims 37-41 wherein the precursor composition is contacted with an acidic solution.

43. The method of claim 42 wherein the precursor composition is contacted with the acidic solution in air.

44. The method of claim 42 wherein the precursor composition is contacted with the acidic solution in an atmosphere having an oxygen concentration which is greater than in air.

45. The method of one of claims 22-44 wherein said precursor has a lattice parameter that is no more than 3.777 Å, and an average size that is no greater than about 30 Å.

46. The method of claim 45 wherein the lattice parameter of said precursor is between about 3.674 and about 3.765 Å.

47. The method of claim 45 wherein the lattice parameter of said precursor is between about 3.689 and about 3.750 Å.

48. The method of claim 45 wherein the lattice parameter of said precursor is between about 3.704 and about 3.745 Å.

49. A method of preparing a catalyst composition comprising an alloy of platinum and copper on electrically conductive support particles, the method comprising:

depositing a copper-containing compound on the electrically conductive support particles;

depositing a platinum-containing compound on the electrically conductive support particles; and,

heating said copper and platinum on the electrically conductive support particles in a reducing atmosphere at a temperature which is greater than about 450°C and less than 800°C for a duration sufficient to form an alloy of copper and platinum,

wherein the concentration of platinum in the catalyst composition is greater than about 50 atomic percent and less than about 80 atomic percent.

50. The method of claim 49 wherein the resulting catalyst composition consists essentially of an alloy of platinum and copper.

51. The method of one of claims 49 or 50 wherein the alloy of copper and platinum has a particle size which is less than 35 angstroms (Å).

52. The method of claim 51 wherein the alloy of copper and platinum has a particle size which is greater than about 20 and less than 30 angstroms (Å).

53. The method of one of claims 49-52 wherein the temperature is greater than about 525°C and less than about 750°C.

54. The method of claim 53 wherein the temperature is greater than about 600°C and less than about 700°C.

55. The method of one of claims 49-54 wherein said duration is about 2 to about 14 hours.

56. The method of claim 55 wherein said duration is about 6.5 to about 13 hours.

57. The method of claim 55 wherein said duration is about 7 to about 12 hours.

58. The method of one of claims 49-57 wherein the copper-containing compound is deposited on the electrically conductive support particles after said platinum-containing compound.

59. The method of one of claims 49-57 wherein the platinum-containing compound is deposited on the electrically conductive support particles after said copper-containing compound.

60. A method of preparing a catalyst composition comprising an alloy of platinum and copper on electrically conductive support particles, the method comprising:

forming a catalyst composition precursor having a platinum concentration that is greater than about 20 atomic percent and less than about 40 atomic percent, by (i) depositing a copper-containing compound on electrically conductive support particles, (ii) depositing a platinum-containing compound on

electrically conductive support particles, and (iii) heating said deposited compounds on said support particles in a reducing atmosphere at a temperature which is greater than about 450°C for a duration of at least 2 hours to form an alloy of copper and platinum; and,

contacting said precursor composition with an acidic solution in air, or alternatively in an atmosphere having an oxygen concentration which is greater than in air, to solubilize a portion of the copper present therein.

61. The method of claim 60 wherein the resulting catalyst composition has a platinum concentration which is greater than 50 atomic percent and less than about 80 atomic percent.

62. The method of claim 60 or 61 wherein the resulting catalyst composition consists essentially of an alloy of platinum and copper.

63. The method of one of claims 60-62 wherein the alloy of copper and platinum has a particle size which is less than 35 angstroms (Å).

64. The method of claim 63 wherein the alloy of copper and platinum has a particle size which is greater than about 20 and less than 30 angstroms (Å).

65. The method of one of claims 60-64 wherein the temperature is greater than about 800°C and less than 900°C.

66. The method of one of claims 60-64 wherein said duration is 2 to about 4 hours.

67. The method of one of claims 60-66 wherein the copper-containing compound is deposited on the electrically conductive support particles after said platinum-containing compound.

68. The method of one of claims 60-66 wherein the platinum-containing compound is deposited on the electrically conductive support particles after said

copper-containing compound.

69. The method of one of claims 60-68 wherein the pH of the acidic solution is greater than 0.5 and less than 3.

70. The method of claim 69 wherein said precursor composition is contacted with the acidic solution in air.

71. The method of claim 69 wherein said precursor composition is contacted with the acidic solution in an atmosphere having an oxygen concentration which is greater than in air.